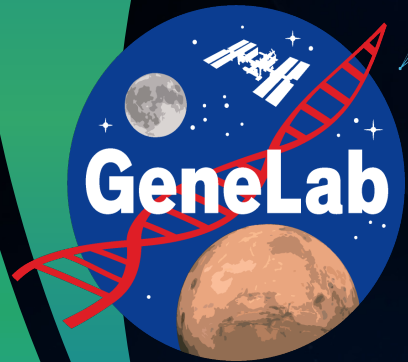
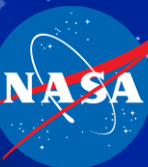


NASA Open Science Data Repository (OSDR) for Space Biology and Precision Health



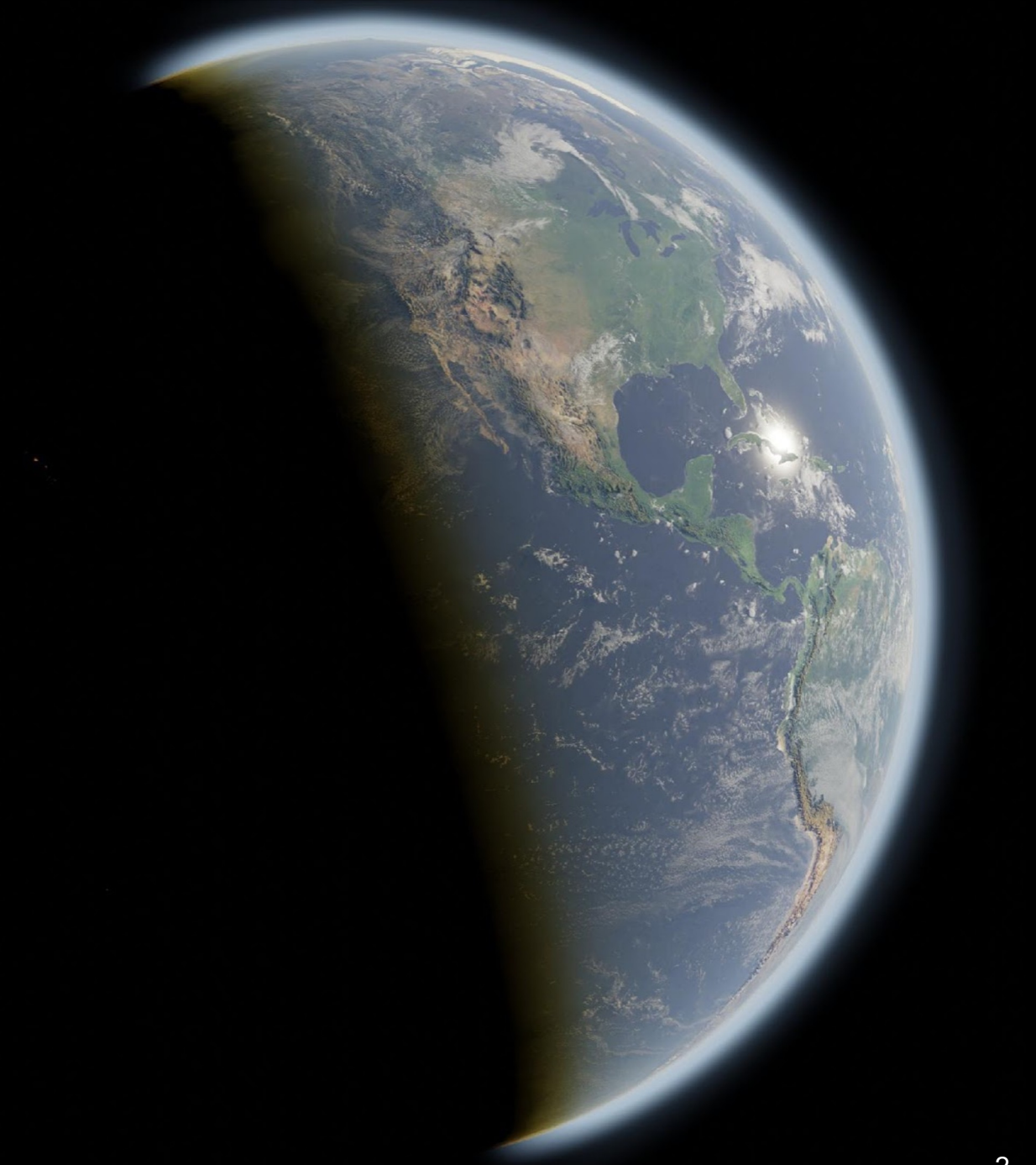
Sylvain V. Costes, Ph.D.
Space Biosciences Research Branch Chief
Project Manager for Open Science for Space Biology (GeneLab/ALSDA)
Lead Scientist for the Radiation Biophysics Laboratory
NASA Ames Research Center

National Aeronautics and
Space Administration



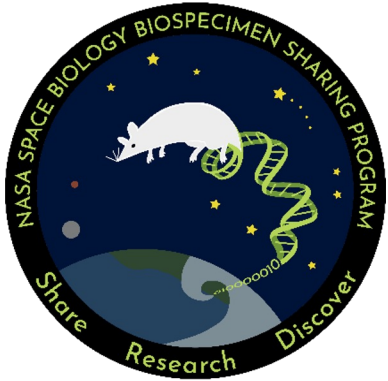
Open Science

“We define open science as a collaborative culture enabled by technology that empowers the **open sharing of data, information, and knowledge** within the scientific community and the wider public to accelerate scientific research and understanding.”



NASA Biological Open Science Resources

Biospecimen Sharing Program (BSP)



Dissection and preservation of rodent tissues from Flight and Ground investigations. Coordination of internal tissue sharing

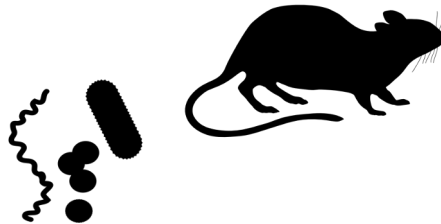


NASA Internal Program

NASA Biological Institutional Scientific Collection (NBISC)



Collection of non-human specimens and space microbial culture

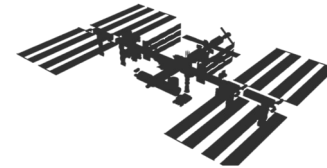


Open-Source Science Programs – Available Globally

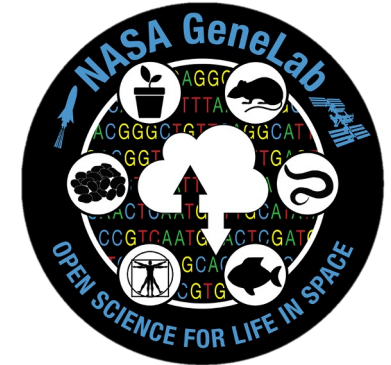
Ames Life Sciences Data Archive (ALSDA)



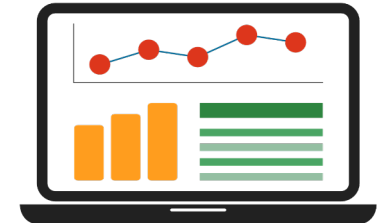
Physiological, phenotypic, bioimaging, behavioral, mission, telemetry data



NASA GeneLab (GL)



All 'omics data

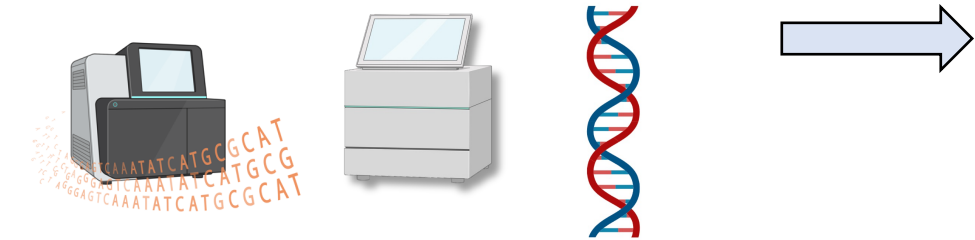


All Relevant Data for Biological, Biomedical, Health, Telemetry Analytics

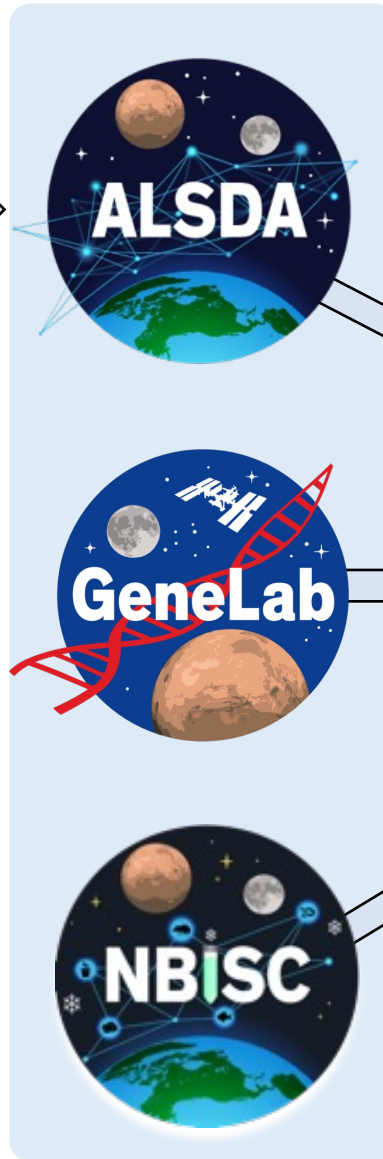
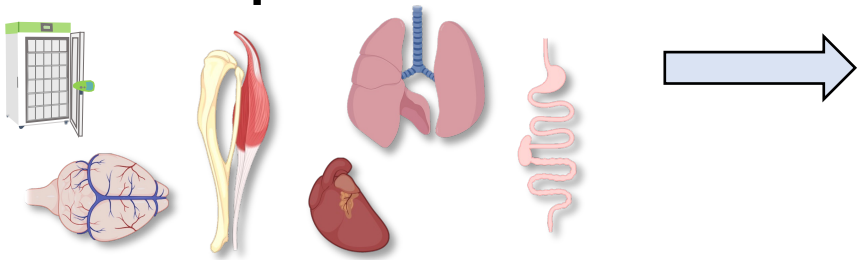
Physiological/Phenotypic/Imaging/ Environmental Telemetry Data



Molecular/Omics Data



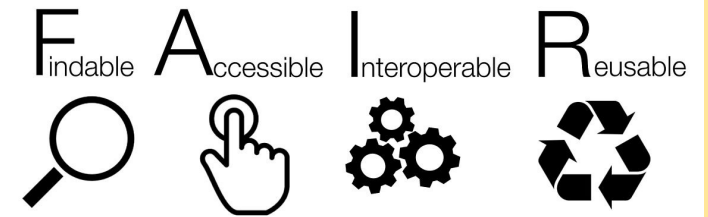
Biospecimens



NASA Open Science Data Repository (OSDR)

osdr.nasa.gov/bio

- Single Point-of-Entry Submission and Self-Service Curation Portal
- Maximally Open Access with Necessary Controls for Sensitive Data
- Data Maximally Findable, Accessible, Interoperable, Reusable



464
Studies

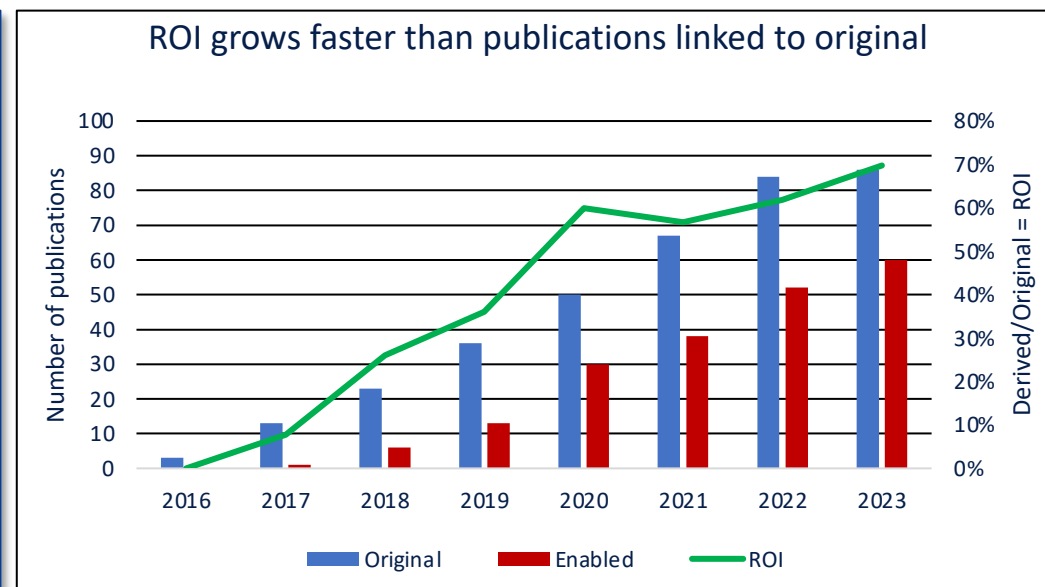
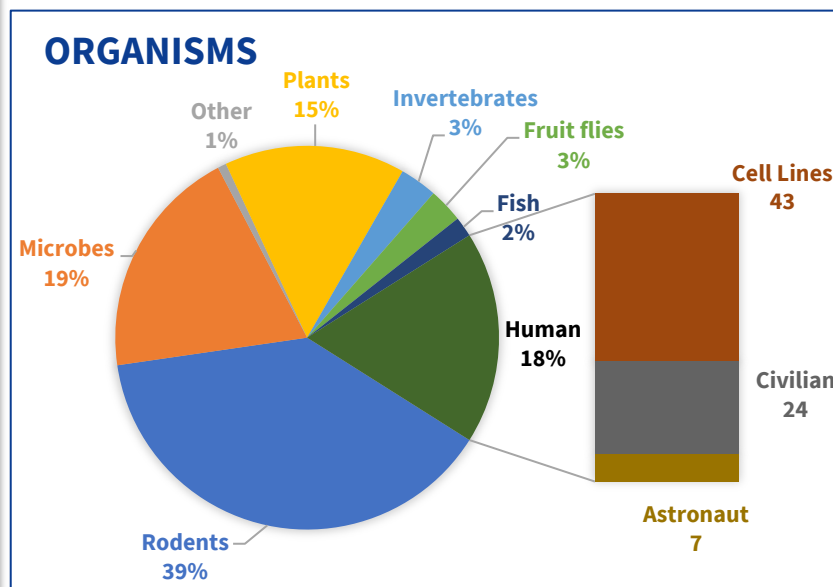
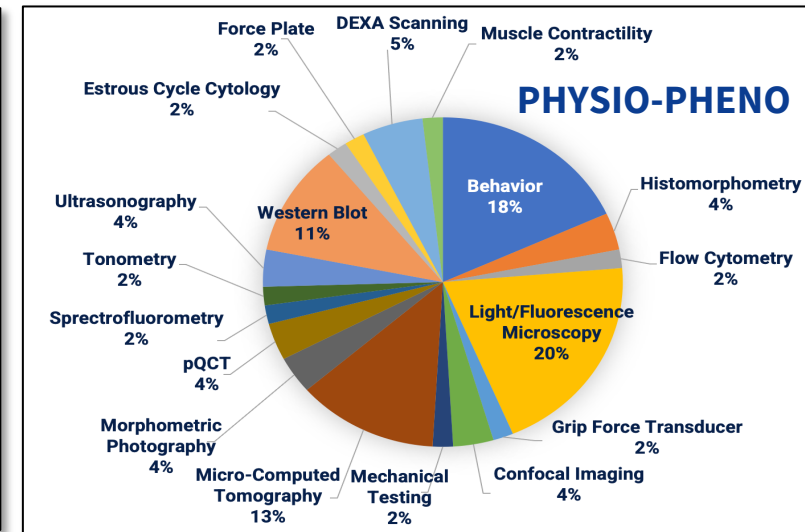
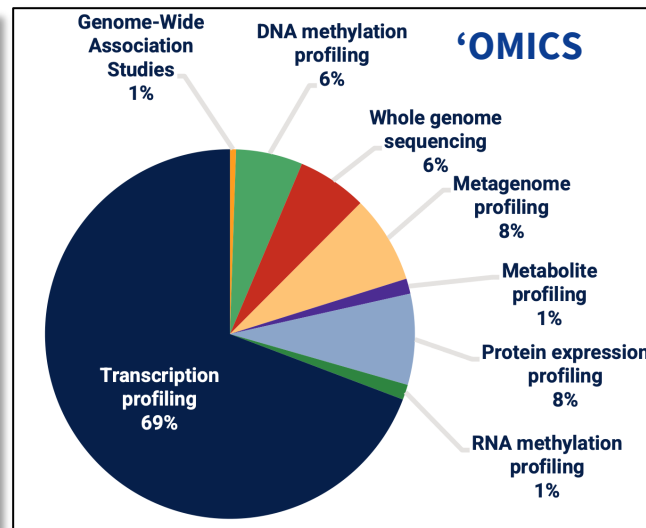
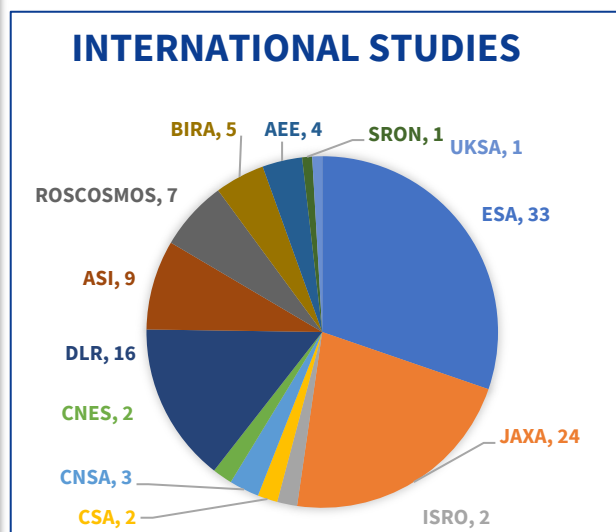
893
Datasets

45
Species

>60
Assays

>150TB
Data

NASA Open Science Data Repository



91

Original Publications Have Data Submitted to OSDR

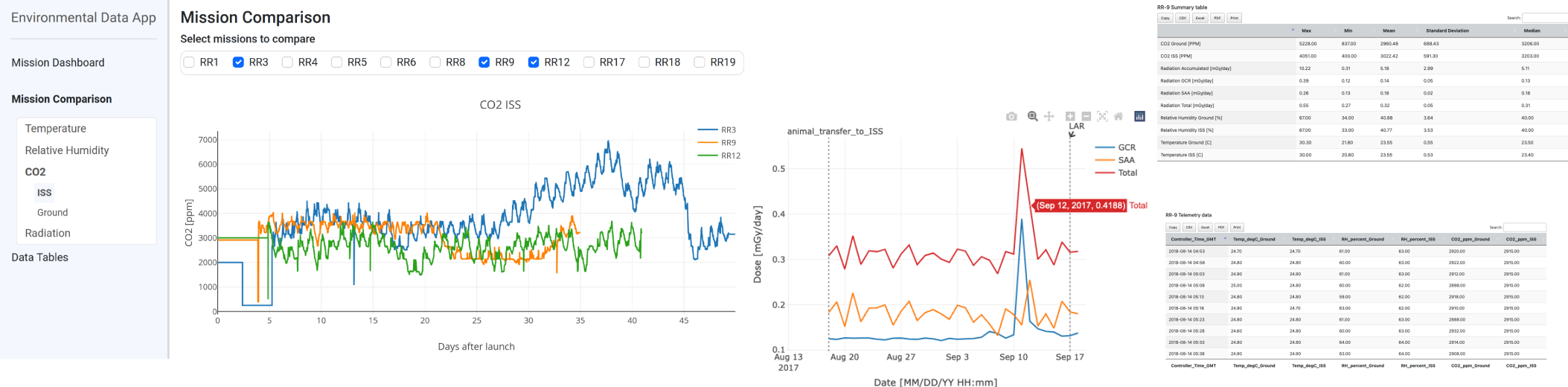
60

Publications Enabled by OSDR Data Mining

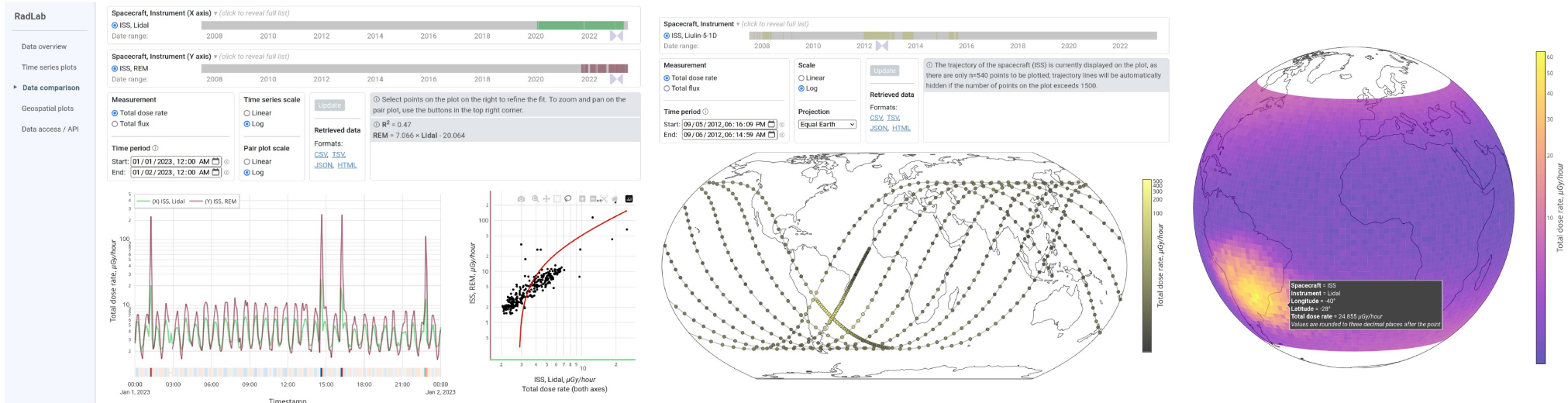
142+

Datasets Used in Enabled Publications

Environmental Data App and RadLab



<https://visualization.osdr.nasa.gov/eda>



<https://visualization.osdr.nasa.gov/radlab>

Open Science Analysis Working Groups: ~600 Members Worldwide

ANIMAL

135 members



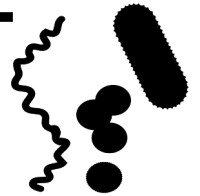
MULTI-OMICS

357 members



MICROBIAL

139 members



PLANTS

129 members



AI/ML

145 members



ALSDA

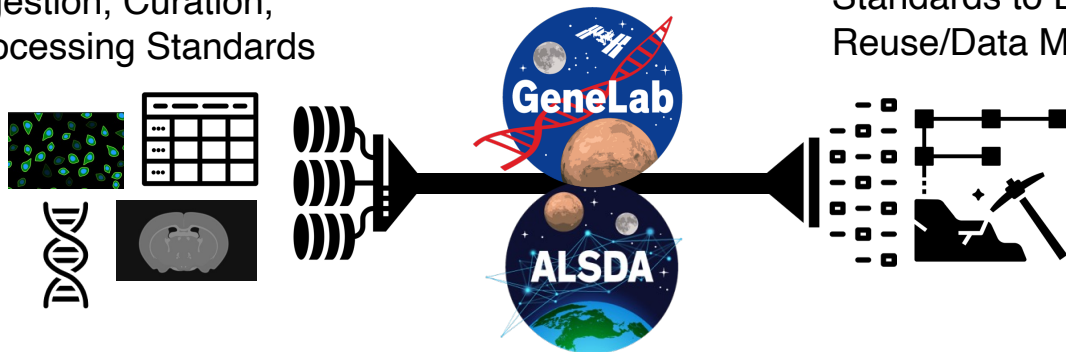
(Physiological/BioMed)

249 members



Feedback on Ingress/Egress Standards

Ingestion, Curation,
Processing Standards



Collaborate on New Studies/Data Mining/Publications

<https://www.cell.com/c/the-biology-of-spaceflight>

<https://osdr.nasa.gov/bio/data/publications.html>



Human Data for Space Biology and Health Research

INSPIRATION 4 N

OSDR Number	Samples	Assays
OSD-569	whole blood	Whole Genome Sequencing
		Clonal Hematopoiesis
		Complete Blood Count
		Long & Short Read RNA-seq
		Epitranscriptomics
OSD-570	PBMCs	Single-Nuclei RNA-seq
		Single-Nuclei ATAC-seq
		Single-Cell TCR-seq
		Single-Cell BCR-seq
OSD-571	blood plasma	Proteomics
		Proteomics (EVPs)
		Proteomics (metabolome)
		cfDNA-seq
OSD-572	skin, oral and nasal swab	cfRNA-seq
		Metagenomics
OSD-573	dragon capsule	Metatranscriptomics
		Metagenomics
OSD-574	skin biopsies, swab	Spatial Transcriptomics
		Metatranscriptomics
		Metagenomics
OSD-575	blood serum	Metatranscriptomics
		Comprehensive Metabolic Panel
		Cytokine Biomarker Panel
		Cardiovascular Biomarker Panel
OSD-630	stool	Immune Biomarker Panel
OSD-656	urine	Metagenomics
		Immune Biomarker Panel

- Upcoming Nature Portfolio 'I4/JAXA/SB Package'
- Credit: Chris Mason's Lab; Overbey et al., 2024
- In Peer Review at *Nature*

Just Confirmed!



- **Commercial Sub-Orbital**
- **Galactic-05 – Flew Nov. 2**
 - Astroskin (ECG, systolic BP, heart rate (HR), breathing rate (BR), skin temperature, activity levels (provided by 3-axis accelerometer) and oxygen saturation in blood (SpO2))
 - Blood Glucose Monitoring Device

Soon!

- Credit: Dr. Shawna Pandya

Vision for Deep Space Biological Research & Precision Health

nature machine intelligence

Review article

<https://doi.org/10.1038/s42256-023-00617-5>

Biomonitoring and precision health in deep space supported by artificial intelligence

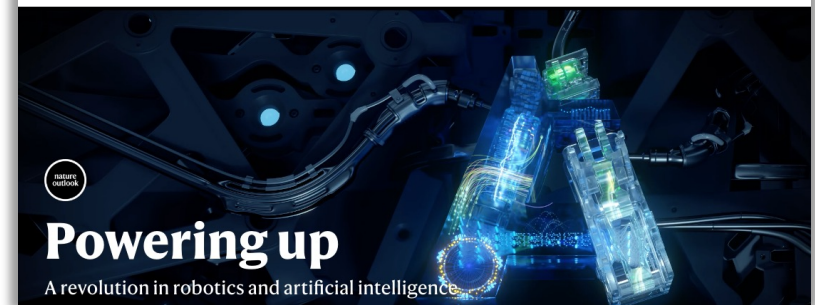
Received: 23 December 2021

Ryan T. Scott^{1,52}, Lauren M. Sanders^{2,52}, Erik L. Antonser

nature

Features Research and reviews Sponsor

in t f



nature machine intelligence

Review article

<https://doi.org/10.1038/s42256-023-00618-4>

Biological research and self-driving labs in deep space supported by artificial intelligence

Received: 23 December 2021

Lauren M. Sanders^{1,52}, Ryan T. Scott^{2,52}, Jason H. Yang³, Amina Ann Qutub⁴,



Lawrence Berkeley National Laboratory



Icahn School of Medicine at Mount Sinai



SALK INSTITUTE FOR BIOLOGICAL STUDIES



University of Minnesota Driven to Discover⁵



HARVARD UNIVERSITY

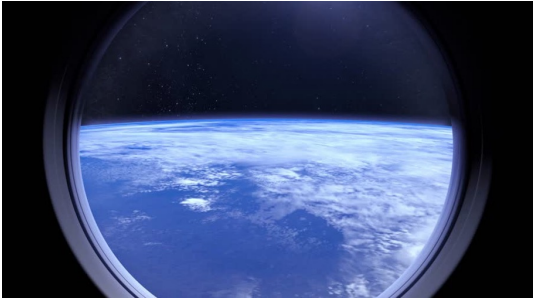


Caltech

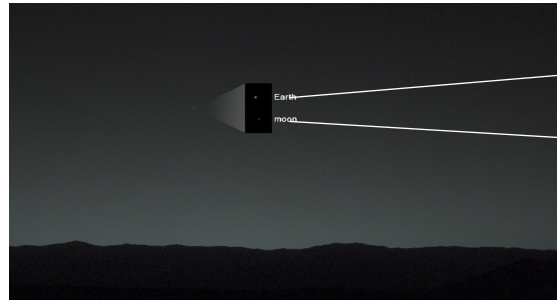


Weill Cornell Medicine

Upcoming Deep Space Exploration and Precision Health



The view from LEO



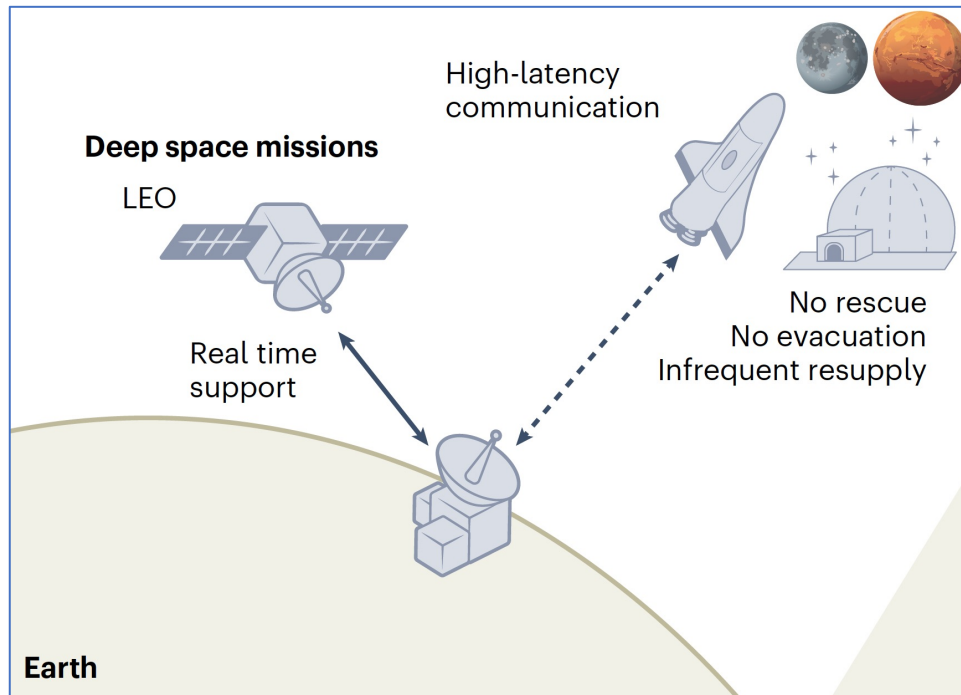
The view from Mars

Earth
Moon

Why is Precision Health Necessary?

- Distance from earth
- High latency communications
- Data bandwidth and power constraints
- Infrequent resupply
- Inability to evacuate
- Limited crew time

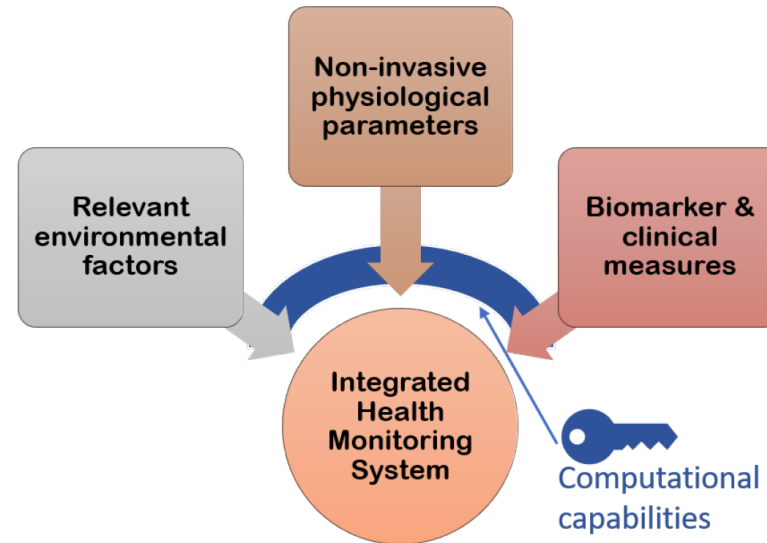
➤ *Enable holistic and continuous picture of the health of the entire spacecraft ecosystem and crew*



Space agencies and industry are well-suited to lead development of precision health for deep space, with feedback to Earth

Precision Space Health: Diverse Data Streams & Design Purpose

Real-time
incorporation of
multiple data
streams



Relevant environmental factors:	atmospheric conditions, gravity, CO ₂ , radiation, etc.
Non-invasive physiological parameters:	wearable devices ¹² , remote monitoring ¹³ , vocal biomarkers ¹⁴ , fatigue assessment ^{15,16} , etc.
Biomarker & clinical measures:	omics analysis, digital biomarker indices, health assessments, traditional clinical evaluation, etc.

Theriot et al., 2021

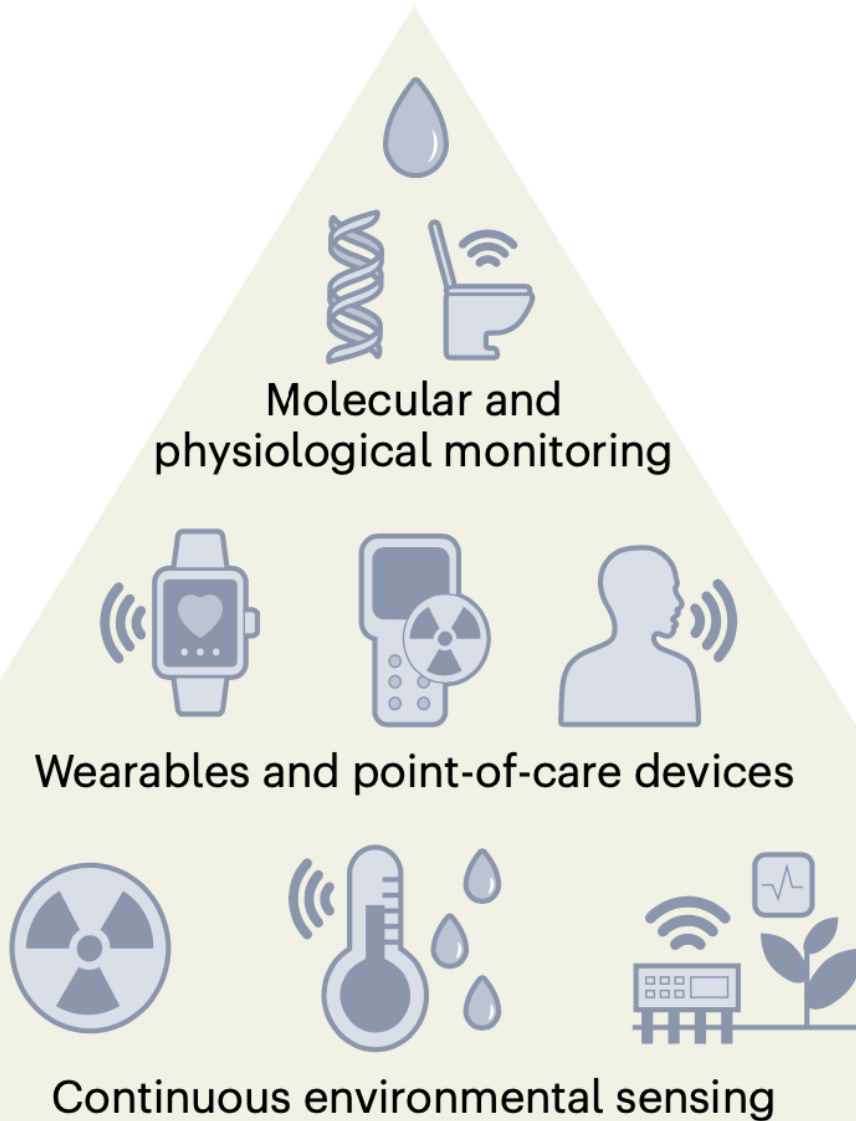
Proactive P4 Medicine:

Predictive
Preventive
Personalized
Participatory

- **Predict** health issues before they become problematic during space flight
- **Prevent** serious medical situations during space travel; **prevent** unnecessary usage of precious pharmaceuticals
- Generate **personalized** data and health plans for each space traveler
- Encourage **participation** in maintaining one's own health prior, during, and after space travel

Hood et al., N. Biotechnol. 2012

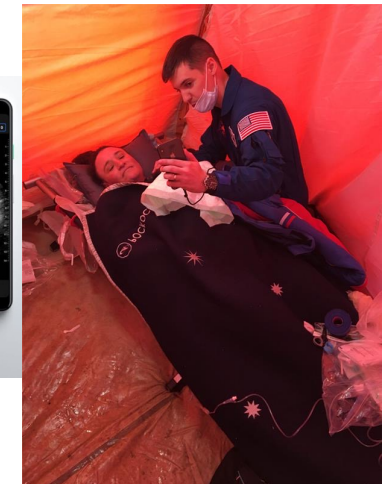
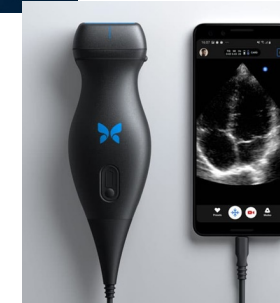
Multi-layered Biomedical, Life Support, and Environmental Monitoring



Scott et al., NMI 2023



*Astroskin: CSA/NASA image with David Saint-Jacques
IQ+ Ultrasound System: Butterfly Network Inc. Palo Alto, CA*

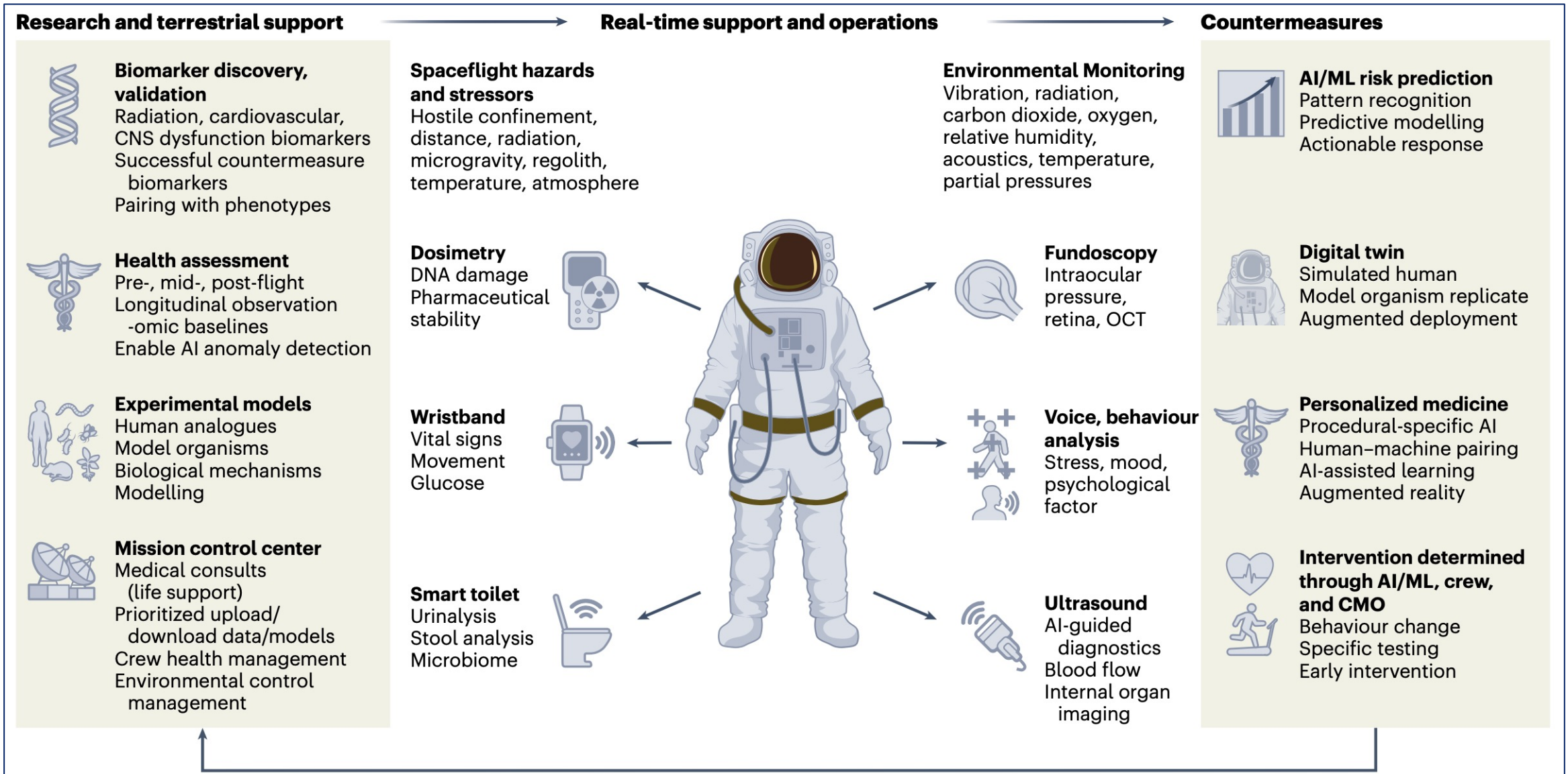


International Space Station Crew Surgeon Dr. James Pattarini and NASA astronaut Serena Auñón-Chancellor test the Butterfly iQ ultrasound in the medical tent at the landing site in Kazakhstan. Image Credit: NASA



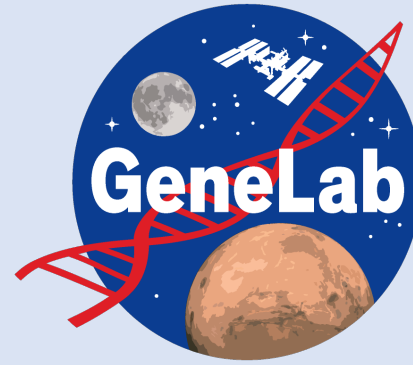
Lantin et al., 2023 PMID: 37693634

Precision Space Health System



Acknowledgements

Open Science for Life in Space Teams



2021 AI/ML Workshop Participants

Open Science Analysis Working Group Members

Support

- NASA Space Biology Program
- NASA Science Mission Directorate
- NASA Human Research Program
- NASA Biological and Physical Sciences
- NASA Postdoctoral Program